

Zebra Mussel Prevention at Glen Canyon NRA in 2007

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Background

History of Zebra Mussel Prevention at Glen Canyon NRA

In 1998, the Utah Aquatic Nuisance Species Action Team (UANSAT) predicted that Lake Powell would likely be the first water body in the western United States (US) to become infested with zebra mussels (*Dreissena polymorpha* and *D. rostriformis bugensis*). The UANSAT made this determination based on the fact that zebra mussels are spread by watercraft being moved from one water body to another. About 100,000 boat passes are sold each year at Glen Canyon National Recreation Area (NRA), with many vessels transported by visitors from the eastern US where the zebra mussels' infestation was widespread in the late 1990's. This prediction prompted further investigation by the Glen Canyon NRA Aquatic Resources Management Branch. The Aquatic Resources Management Branch assessed the number of boats that came from zebra mussel infested states by monitoring license plates in parking lots. The number of boats trailers counted from zebra mussel infested states supported UANSAT's determination that Lake Powell was under considerable threat of becoming infested.

In response to the threat posed by watercraft from the eastern United States, Glen Canyon NRA began the Zebra Mussel Prevention Program in 2000. This program screened visitors for high-risk watercraft at entrance stations. High-risk vessels, defined as vessels that have been used in zebra mussel infested waters within 30 days without any decontamination treatment, were encouraged to receive a free professional decontamination from ARAMARK, Glen Canyon NRA's only concessioner at the time. Starting in 2003, high-risk vessels were required to be decontaminated, through the Superintendent's Compendium, prior to launching on Lake Powell. Other elements of the Zebra Mussel Prevention Program included public education measures in the form of articles in the Glen Canyon NRA newspaper, aquatic nuisance species brochures, a notice on the traveler information system, and local radio segments.

Early monitoring for adult zebra mussels (1999-2002) in the lake was focused on inspecting docks and buoys (Figure 1). In 2002, the Zebra Mussel Prevention Program began using specially designed artificial substrates to check for zebra mussel colonization. These substrates were checked periodically to allow early detection of potential zebra mussel populations. With the discovery of zebra mussels in Lake Mead and other western water bodies in 2007, the monitoring program and prevention strategy were enhanced.

Discovery of Zebra Mussels in the Western United States

Zebra mussels were first discovered in the western US on 6 January 2007 in Lake Mead National Recreation Area at the Las Vegas



Figure 1. Early monitoring for zebra mussels in Lake Powell.



Figure 2. Quagga mussels in Lake Mead.

Boat Harbor. The species of zebra mussel discovered in Lake Mead was *Dreissena rostriformis bugensis*, commonly referred to as the "quagga mussel" (Figure 2). Subsequent scuba dives in Lake Mead revealed populations throughout Boulder Basin. It has been estimated that mussels have been in deep water locations of Lake Mead for 3 to 5 years.

Within weeks of the initial discovery in Lake Mead, other locations downstream including Lake Havasu, Lake Mohave, the Colorado River Aqueduct, and the Central Arizona Project Aqueduct were

all discovered to be infested with zebra mussels. It is expected that with time, more western US water bodies will become infested. Zebra mussels have not been found upstream of Glen Canyon NRA and are not currently believed to be in Lake Powell.

Zebra Mussel Prevention at Glen Canyon NRA in 2007

Initial Response to Western Invasion

With the discovery of zebra mussels in Lake Mead, Glen Canyon NRA and park concessionaire divers searched for adult mussels in marina areas of Lake Powell (Figure 3). Wahweap and Stateline Marinas were inspected by Glen Canyon NRA divers on 24 January 2007. Antelope Point Marina was inspected by concession divers in January. Bullfrog and Halls Crossing Marinas were inspected by Glen Canyon NRA and concessioner divers on February 12 – 13. None of these searches resulted in the discovery of zebra mussels.

The Zebra Mussel Prevention Program was greatly expanded in 2007 in order to deal with the greater risk of infestation at Lake Powell. Zebra mussel prevention was designated as the top priority of Glen Canyon NRA by the park's Superintendent. A Zebra Mussel Interdisciplinary Team was created to address the needs of a more comprehensive zebra mussel prevention program for the park. The team consisted of representatives from all divisions and major operations within the park including Facilities Management,



Figure 3. Divers searching Wahweap Marina for adult mussels.

Business Management, Interpretation, Resource Management, Law Enforcement, Administration, Fees, and Management. Team meetings began in January, shortly after the discovery of zebra mussels in Lake Mead, and were held every one or two weeks until mid-July. Efforts of the interdisciplinary team focused on establishing stronger regulations to prevent infestation, establishing a self-certification program for boaters, expanding education and public outreach, improving decontamination capabilities, and preparing funding requests.

Glen Canyon NRA created and implemented a unique certification program that had not been undertaken by any other entities previously. This program is applicable to all aquatic nuisance species, not just zebra mussels. This type of program is something that could be implemented by any park or management agency that has the ability to enforce the certification requirement. Even without the ability to regulate, it is an excellent educational tool.

Interagency, Regional, and National Cooperation

Glen Canyon NRA has participated on a regional and national level for many years in interagency efforts to address aquatic nuisance species issues, primarily through the U.S. Fish and Wildlife Service-organized 100th Meridian Initiative and the Utah Aquatic Nuisance Species Action Team. With the discovery of quagga mussels in the western US, Glen Canyon NRA assumed a central role within these organizations. Additionally, a variety of meetings were conducted with Lake Mead NRA, Grand Canyon National Park, Utah Division Wildlife Resources, Utah State Parks, Arizona Game and Fish, park concessionaires (ARAMARK and Antelope Point Holdings), Commercial Use Authorization permit holders, and Grand Canyon River Guides Association, among others. Several public meetings were conducted to inform the public of the issue and to provide an opportunity to provide feedback to Glen Canyon NRA. A training titled Watercraft Inspection Training for Prohibited Aquatic Nuisance Species was conducted by the US Fish and Wildlife Service and Pacific States Marine Fisheries Commission. The training was widely attended by the public and staff from the National Park Service, Utah Division of Wildlife Resources, Arizona Game and Fish, ARAMARK, and Antelope Point Holdings. This training was organized by the Utah Division of Wildlife Resources.

In April, the National Park Service created a service-wide prevention and response guide through the All Risk Incident Command System (Western Quagga Response Team). The NPS Quagga/Zebra Mussel Infestation Prevention and Response Planning Guide (NPS Quagga/Zebra Plan) was created to be used by all National Park Service units with aquatic resources. This guide was largely based on the prevention actions of Glen Canyon NRA and the rapid response/containment planning at Lake Mead NRA. Three Glen Canyon NRA employees were included on the incident team.

New Regulations

The regulation created in the Superintendent's Compendium in 2003 requiring high-risk vessels to be decontaminated prior to launching on Lake Powell was updated in 2007 to support the expanded Zebra Mussel Prevention Program. The compendium now requires

that a "Mussel Free" certificate is displayed on the dashboard of any vehicle with an attached boat trailer. This certificate indicates that the vessel associated with the trailer does not pose a risk for transporting zebra mussels. The "Mussel Free" certificate could be obtained at the entrance stations following the screening of boat history conducted by entrance staff or through a self-certification process. The self-certification process allows visitors to screen their own boats when entrance booths are closed. Vessels transported to Glen Canyon NRA that do present a risk can obtain their certificate after a professional decontamination. Self-certification packets were available on the Glen Canyon NRA website and at the top of each launch ramp. The dashboard certificate approach provides a mechanism through which the regulations can be enforced. The new language in the compendium now states:

36 CFR §1.5 - PROHIBITED OPERATIONS

Vessels that have been used within 30 days in states infested with zebra mussels as identified in park information materials will not be allowed on park waters until completing the prescribed abatement process.

Operators of vehicles towing boat trailers parked within the NRA are required to display on the dashboard of their vehicle a "clean boat" inspection certificate issued by the NPS or authorized inspection service. Failure to display the required certificate may result in issuance of a violation notice for failure to comply with Superintendents conditions.

Citations for violations of the new certification regulations were postponed for the 2007 summer season in order to provide visitors a chance to become familiar with the program. In lieu of citations, vehicles with empty trailers that did not display a "Mussel Free" certificate received a "This could have been a ticket!" informational pamphlet placed on their windshield. The pamphlet alerted the visitor that they were not in compliance with Glen Canyon NRA regulations and provided information about the prevention program.

Dashboard Certificate Compliance

The percentage of vehicles complying with the requirement for a "Mussel Free" dashboard certificate varied through the summer. While efforts were not made to monitor this compliance in a scientifically sound manner, sporadic monitoring was conducted and compliance varied from between 70-90% depending on the location and time of year. An estimated 3000 "This Could have Been A Ticket" brochures were placed on windshields of vehicles that did not have a "Mussel Free" certificate displayed in 2007.

Education

An extensive effort was made to educate visitors to Glen Canyon NRA, especially those with watercraft, about the threat of zebra mussels and the role boaters play in transporting aquatic nuisance species. The Zebra Mussel Interdisciplinary Team developed strategies to inform the public quickly, accurately, and clearly. Initial efforts included radio spots on the local radio station, television news interviews, interviews with local and regional newspapers, and press releases. The Glen Canyon NRA zebra mussel website was updated to include zebra and quagga mussel information, as well as the new requirements for boaters. A telephone hotline was also created, so that visitors could easily access the latest information on zebra mussel prevention at Glen Canyon NRA.



Figure 4. Launch ramp sign at Wahweap.

Brochures were made available at visitor centers and at other places frequented by boaters. Local businesses were encouraged to provide information on zebra mussels. The brochures were given to visitors entering the park at entrance stations and were made available at visitor centers. The nation-wide "Zap the Zebra" brochures, designed by the US Fish and Wildlife Service, were also widely distributed. Signs were placed at the entrance booths, self-certification stations, and launch ramps to inform visitors of vessel certification requirements (Figure 4).

Interdiction

Screening

Screening for high risk watercraft at the entrance stations (Figure 5) in 2007 was modified to deal with the large number of boats expected to need decontamination. Park visitors were questioned by entrance station staff, using standardized questions, to determine the history of their watercraft.



Figure 5. Wahweap South entrance.

If a watercraft had been in zebra mussel infested waters less than 30 days prior to entering Glen Canyon NRA and had not been washed and allowed to completely dry for at least 5 days, the vessel was considered high-risk and the entrance station staff provided the visitor with a coupon and instructed them to have their vessel decontaminated before launching. A questionnaire was used by staff to document the history of high-risk boats. Boats that had not been in infested waters or had been properly decontaminated were given a "Mussel Free" certificate to display on their dashboard. The automated fee machines were programmed to ask the same questions as entrance staff and inform a visitor when decontamination was required for

their vessel. Any watercraft that was decontaminated was given a “Mussel Free” certificate after the procedure was completed.

A visitor self-certification process was established to extend the prevention program to times when entrance stations were closed, accommodate the large number of contaminated boats that were expected to need decontamination, and expedite the certification process. Self-certification packets consisted of information on zebra mussels, a flow chart to determine if a vessel met the requirements to self-certify, directions to decontamination stations, and a “Mussel Free” certificate for the visitor to sign and place on their dashboard. These packets were available on the Glen Canyon NRA webpage and at self-certification stations near the launch ramps. Self-certification allowed visitors to ensure that they complied with the certification regulations before they arrived at the park.

Results of Screening

Four hundred eighty (480) vessels were identified at entrance stations as high-risk in 2007. High-risk vessels are those that have been in zebra mussel infested waters within the past 30 days and had not been washed and allowed to dry for at least 5 days. The number of high-risk vessels entering the park peaked in the month of July at 162. The week with the greatest number of high-risk vessels entering the park was 02 – 08 July with 47 vessels (Figure 6). The majority of high-risk vessels, 79%, were identified at the Wahweap entrance stations, comprising of Wahweap South, Wahweap North, and Lone Rock. Fourteen percent of the high-risk vessels were identified at Antelope Point Marina, followed by 5% at the Bullfrog Marina entrance station. No high-risk vessels were identified at Halls Crossing. This may be due to the location of the marina in relation to infested waters and/or the fact that the entrance was not staffed. Screening at Halls Crossing was conducted through an automatic fee machine and by the self-certification packets only.

The majority of high-risk vessels entering the park had recently been in the Lakes Mead, Mohave, or Havasu (Figure 7). A small number, 5%, had been used on the Lower Colorado River downstream of Lake Mead. Several vessels, 2%, had been used on more than one lake within the past 30 days. About 10% of the high-risk vessels, 41 vessels, were identified as coming from infested states east of the Rocky Mountains; this number is comparable to the number of high-risk vessels entering the park in previous years. Five vessels that had been in Lake Pleasant, in central Arizona, were mistakenly identified as high-risk by entrance station staff and decontaminated. These statistics only include data from completed questionnaires or inspection forms from the entrance stations. About 5% of the questionnaires were returned incomplete and were not included in this analysis. Furthermore, this analysis does not consider any individuals who may have identified their vessels as high-risk through the self-certification process and had their vessel decontaminated.

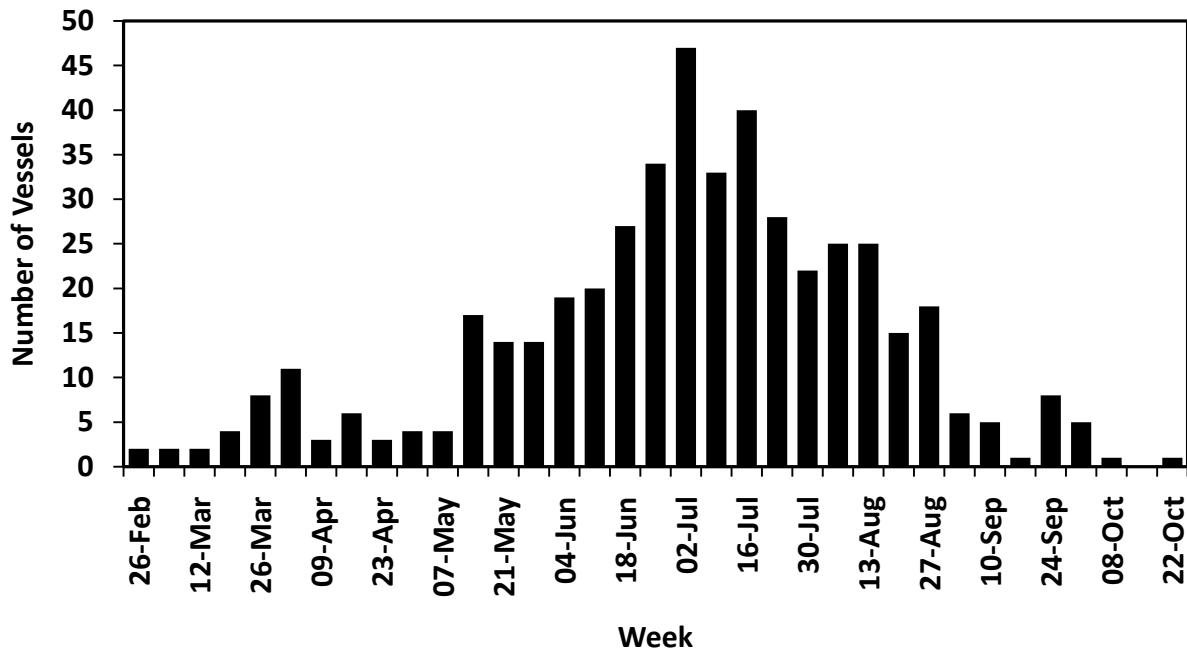


Figure 6. Number of high-risk vessels entering Glen Canyon NRA identified each week (Monday through Sunday) at the entrance stations.

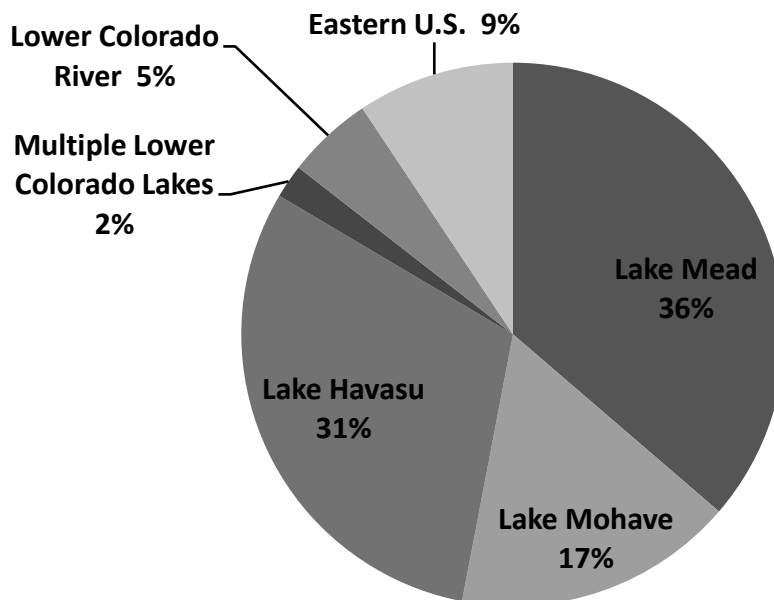


Figure 7. Previous location of high-risk vessels entering Glen Canyon NRA as identified at entrance stations.

Decontamination

In order to meet an increased demand for decontaminations and to prevent wastewater runoff, specialized washing facilities were purchased for the Wahweap and Bullfrog Marinas (Figure 8). The facilities use water hot enough to kill zebra mussels instantly ($>140^{\circ}\text{F}$). Wastewater is captured and recycled. The Wahweap decontamination station is capable of decontaminating up to four boats at once, and the Bullfrog station can decontaminate up to two boats at once. The panels on the outside of the decontamination stations were customized with an aquatic nuisance species message.

Beginning in the summer of 2007, decontamination was no longer offered for free. The number of vessels requiring decontamination was expected to be too great to be covered entirely by the concessioners. The boat decontamination fee was set at \$50 an hour, and charged in 15-minute increments. In the summer of 2007, most vessels took 15 to 30 minutes to decontaminate, resulting in charges of \$12.50 to \$25. The Wahweap decontamination station was open prior to Memorial Day. The Bullfrog decontamination station was not operational until early July. Antelope Point and Halls Crossing continued to use their existing boat decontamination facilities, consisting of portable hot water and steam washers.

Because decontamination stations are not located at the entrance stations, high-risk vessels that are identified at the entrance booths are released and expected to report to the decontamination facilities prior to launching. Releasing these vessels gives unscrupulous visitors an opportunity to launch without decontamination even if their vessel has been identified as a high-risk vessel. The potential for visitors to avoid the decontamination has existed since the program began and may have increased in 2007 with the new charge for decontamination. To minimize non-compliance, entrance station staff have collected identifying information about the visitor and/or vessel as part of the questionnaire, and stated clearly to the visitor that the decontamination is required. In previous years, staff contacted National Park Service dispatch in the presence of the visitor to make notification that a high-risk vessel had been identified and was being directed to the decontamination facilities.

The Zebra Mussel Interdisciplinary Team considered several options to minimize decontamination non-compliance including law enforcement escorts, and entrance station staff contacting dispatch or the decontamination station in the presence of the visitor when high-risk vessels were identified. Because of personnel limitations, rangers were not



Figure 8. Front and back sides of the decontamination facility at the Wahweap Marina.

available to escort high-risk vessels from the entrance station to the decontamination facilities. Also, although it had been done in the past, the Fees Branch of the park could not commit to contacting dispatch or the decontamination station in 2007 each time a high-risk vessel was identified. Entrance station staff did continue to collect the visitor's name, driver's license number, and license state in order to encourage compliance. Visitors with high-risk vessels were given an orange coupon that they had to turn in at the decontamination facility.

Antelope Point marina used slightly different decontamination procedures than the marinas operated by ARAMRK (Wahweap, Bullfrog, and Halls Crossing). At the Antelope Point entrance station, visitors were asked the same questions to determine boat history, but the entrance station questionnaire was not used. At the decontamination area, an inspection of the watercraft was performed by the boat shop employees, looking for wet/dirty areas of the watercraft or anything that could potentially be carrying zebra mussels. If the boat appeared clean and did not have any areas that could be harboring zebra mussels, the boat was not required to be decontaminated. This inspection followed a draft protocol established by the Glen Canyon NRA that is expected to be fully implemented in conjunction with the entrance station questionnaire at all marinas in 2008.

Decontamination Compliance

Watercraft decontamination compliance was determined by matching coupon numbers collected from the decontamination facility to questionnaire numbers returned from the entrance stations. The percentage of identified high-risk vessels that were compliant with decontamination requirements was approximately 83%. Two of the boats that were decontaminated were visibly infested with adult quagga mussels. Several factors affect the accuracy of this analysis. Antelope Point marina entrance stations are operated independently of the National Park Service and the staff did not provide coupons at the entrance stations to be turned in at the decontamination facility. The decontamination facility is within a short distance from the entrance station, and Antelope Point did not feel there would be any advantage to providing a coupon. The data is further impacted by commonly poor quality of data collection. As discussed earlier, questionnaires were not always completely filled out by entrance station staff. There are several known instances of watercraft that were decontaminated, but no questionnaires were completed. It is also likely that there were vessels that were decontaminated, but did not have a coupon returned.

Monitoring in 2007

Artificial Substrate Samplers

Since 2003, monitoring for adult mussels had been performed using artificial substrates hung from docks and buoys for zebra mussels to colonize, if present (Figure 9). The substrates consisted of a 6 to 10 inch long piece of 2 inch diameter PVC pipe with mesh inside. These substrates were hung in the water at a depth of approximately 6 feet. The substrates were checked monthly during summer months each year. The artificial substrates were designed to detect the more common species of zebra mussel (*Dreissena*

polymorpha), which lives at shallower depths than quagga mussels. Similar substrates used in Lake Mead did not show the presence of deeper living quagga mussels for several years after they were introduced.

In 2007, the artificial substrates in Lake Powell were redesigned to better monitor for both zebra and quagga mussels. Black ABS pipe was used for the substrates instead of white PVC in consideration of zebra mussels' photophobia. Additionally, the substrates were hung at three depths (10ft, 20ft, and 30ft) to better target both species of zebra mussels. Thick monofilament line was used for hanging substrates in the hope that there would be less tampering by visitors and that zebra mussels may also colonize the monofilament line. It is now suspected that sunlight and/or friction from wave action weakened the monofilament line over time, due to the high rate of substrate disappearance. In late summer, the Utah Department of Wildlife Resources took responsibility for this component of the monitoring program.

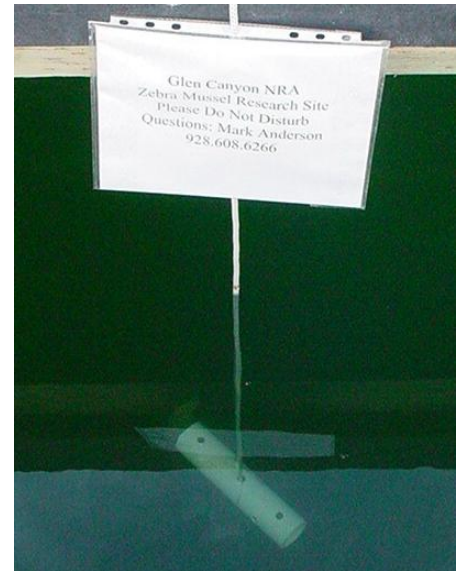


Figure 9. Artificial substrate sampler.

Plankton Sampling (veligers)

In addition to sampling for adult mussels using artificial substrates, sampling was also conducted for the planktonic larval life-stage of zebra mussels called veligers (Figure 10). Sampling for veligers can provide earlier detection of an infestation than monitoring for adult mussels. Initial plankton samples were collected by the Arizona Game and Fish at Lees Ferry in the Lake Powell tailwaters in mid-June. These samples were sent to the Bureau of Reclamation (BOR) laboratory in Denver for both microscopic, using polarized light, and genetic analysis using Polymerase Chain Reaction (PCR) techniques. No veligers were identified in these samples.

On 19 July, two replicate samples were collected in Lake Powell near the Glen Canyon Dam and Wahweap Marina by the US Geological Survey (USGS) – Grand Canyon Monitoring and Research Center (GCMRC) and sent to the BOR laboratory for analysis. The BOR laboratory reported positive microscopic results for both samples and



Figure 10. Glen Canyon NRA and Utah Division of Wildlife plankton sampling to detect larval mussels.

positive results for one of the replicates using PCR analysis.

Additional sampling was conducted in an effort to confirm the initial reports from the BOR laboratory. Samples were collected from marinas in the vicinity of the reported veligers. Depth-specific samples were collected in cooperation with USGS – GCMRC and Utah Department of Wildlife Resources (UDWR). Samples were collected with additional replication for analysis by other laboratories to confirm the BOR findings.

On August 6, four sample replicates (0 – 50 meter depth) were collected at each of four locations between the Wahweap Marina and the Stateline launch ramp. Two of the replicates were sent to the BOR laboratory for analysis, one was sent to Portland State University Center for Lakes and Reservoirs for microscopic analysis, and one was analyzed microscopically in the Glen Canyon NRA laboratory. Positive microscopic results were detected by the BOR laboratory, but not by either Portland State University or the Glen Canyon NRA (GLCA) laboratory (Table 1).

Table 1. Results of replicate samples collected in the vicinity of Wahweap Marina, Lake Powell.

Site	Rep A (GLCA)	Rep B (PSU)	Rep C (BOR)	Rep D (BOR)
WW1	0	0	7	9
WW2	0	0	8	13
WW3	0	0	1	6
WW4	0	0	2	4

The depth-specific sampling was conducted on August 14th in Wahweap Marina in an attempt to locate an adult population. This sampling was conducted jointly by the USGS – GCMRC, UDWR, and Glen Canyon NRA. Samples were immediately analyzed microscopically in the Glen Canyon NRA laboratory. No veligers were detected in any of these samples.

Additional replicated samples were collected in cooperation with UDWR and GCMRC at Wahweap Marina, Antelope Point Marina, Halls Crossing Marina, Bullfrog Marina, Good Hope Bay, the Rincon area, and other remote locations. Only some of these samples have been processed. No veligers have yet been detected in uplake or remote areas of Lake Powell.

As of January 2008, the results reported by the BOR laboratory have not been confirmed by a second laboratory. It is possible that the BOR laboratory may have misidentified ostracods, seed shrimp, as zebra mussel veligers in the microscopic procedure. Both organisms look similar under polarized light (Figures 11 and 12). Once an organism is located using polarized light, it must be further examined

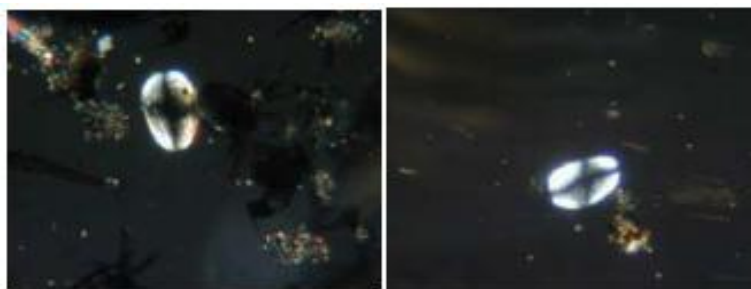


Figure 11. Photographs of organisms identified as veligers by the BOR in August 6 Wahweap Marina.

under high magnification bright field light to determine if it is a mussel, ostracod, or another type of organism.

Positive PCR results in the BOR laboratory seem to support the BOR's determination that organisms in Lake Powell samples are zebra mussels. It should be noted that while PCR is an established procedure in molecular biology, procedures must be developed to use this technology for each species of interest. At this time, PCR methodology has not been developed to its fullest capability for zebra mussel species. Only 3 laboratories, which work closely together, are attempting to use PCR to identify zebra mussel species in the entire country. Current PCR methodology cannot distinguish between zebra and quagga mussels, uses techniques that were developed over ten years ago, is not quantitative, and is very susceptible to cross-contamination in the laboratory due to the extreme sensitivity of the procedure.

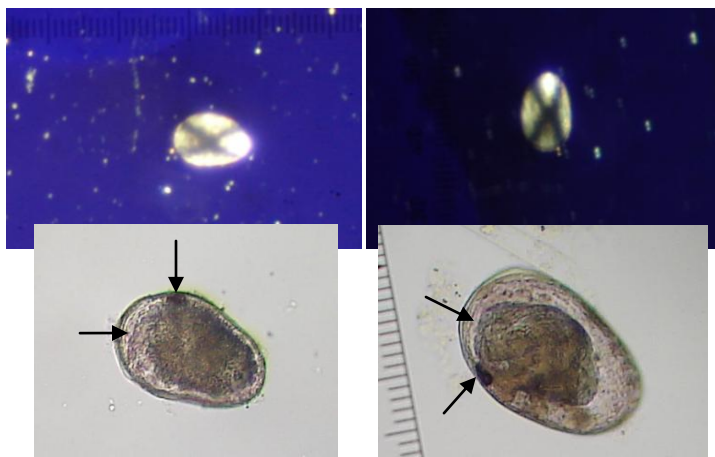


Figure 12. Photographs of ostracods identified by the Glen Canyon NRA in August 6 samples from Wahweap Marina. Arrows on high resolution images indicate legs and eyespots diagnostic of ostracods.

Positive results of PCR testing by the BOR seems to confirm the presence of zebra mussel genetic material in Lake Powell; however, the test results do not indicate if the mussel flesh detected was alive or dead when collected or how much was in the original sample. As discussed, nearly 500 boats suspected of carrying zebra mussels were decontaminated immediately prior to launching in 2007. Decontamination procedures focus on killing any mussels present as opposed to removing all flesh from contaminated boats. Any dead zebra mussel flesh that remains on a boat after decontamination could be released into the lake when the boat is launched and potentially be detected with PCR, especially near launch ramps. This potential "ramp effect" is a consequence of the extreme sensitivity of PCR, which can detect even trace amounts of genetic material.

Underwater Search

The initial response of Glen Canyon NRA to the report that veligers were found in Lake Powell included trying to locate any adult population. In early August 2007, over 140 hours of scuba diver time was spent trying to locate an adult



Figure 13. Glen Canyon NRA's remotely operated submarine vehicle.

population in Wahweap Marina, where veligers had been reported. Also in August, the Glen Canyon NRA's Remote Operated Vehicle (Figure 13) was used to search at depths that were too deep for divers (greater than 130 feet). It was hoped that if an isolated adult population had been found, for example on the bottom of a boat, it may have been possible to remove or eradicate the population from the lake. No adult zebra mussels were ever identified with these efforts.

Containment

Despite the uncertainty and discrepancy in findings between the laboratories, Glen Canyon NRA will operate under the assumption that Lake Powell is infested with zebra mussels in regards to any containment strategy. Efforts are underway to implement recommendations in the National Park Service Quagga/Zebra Mussel Plan to contain any possible infestation.

With the potential for Lake Powell to contain zebra mussels, changes were made to requirements for entities that conduct business within Glen Canyon NRA. New permit conditions were placed on concessioners and commercial use authorization (CUA) operations after the potential discovery of larval zebra mussels in Lake Powell. The new regulations require that all vessels moored on Lake Powell be decontaminated if the vessel is removed from Lake Powell and going to another water body. Additionally, any vessel that may leave the concessioner's or CUA operator's control within 30 days of removal from the lake must also be decontaminated. Vessels that are simply being removed from slips for maintenance and will be returned to Lake Powell are not required to be decontaminated. Also, if a vessel is being removed from the lake and going to dry storage, always remaining under the concessioner's or CUA operator's control, are not required to be decontaminated.

Budget

Funding for the Zebra Mussel Prevention Program and all elements of the Expanded Action Plan in 2007 was provided by park base budget, Water Resources Division Emergency funds, and the Colorado Plateau Cooperative Ecosystem Study Unit. Assistance was provided by, USGS – GCMRC (veliger sampling), U.S. Fish and Wildlife Service's 100th Meridian Initiative (veliger sample processing), and the U.S. Bureau of Reclamation (veliger sample processing). The Honda Corporation assisted Glen Canyon NRA by designing and printing brochures about Glen Canyon NRA's Zebra Mussel Prevention Program.

Especially noteworthy assistance was provided by the Utah Division of Wildlife Resources (UDWR). UDWR funded 40,000 Zap the Zebra brochures for distribution at Glen Canyon NRA, assumed responsibility for artificial substrate monitoring, assisted with veliger sampling and sample shipping, and generally aided the park as a valuable collaborator. The Glen Canyon NRA entrance stations closed in early November 2007. From that time through mid-December, the UDWR hired two employees to educate boaters about Glen Canyon NRA's requirements at Wahweap and Bullfrog, mainly on the launch ramps.

The park base budget supported salaries and internal planning efforts within the park, especially in support of the Zebra Mussel Prevention Interdisciplinary Team.

The self-contained decontamination stations at Wahweap and Bullfrog Marinas were funded through “set-aside” funds. These funds are generated by the Concessions contract with ARAMARK. These funds can be used for projects that benefit the National Park Service, ARAMARK, and Glen Canyon NRA visitors. Purchase and installation of the new decontamination stations cost about \$400,000.

The Colorado Plateau Cooperative Ecosystems Study Unit of the National Park Service contributed \$3,000 to assist in funding an intern as Zebra Mussel Prevention Program Coordinator. The intern coordinator gathered and tallied records including coupons and questionnaires, prepared minutes from the Zebra Mussel Interdisciplinary Team meetings, lead artificial substrate monitoring activities, drafted this report, and assisted the Glen Canyon Zebra Mussel Prevention Program Director in all aspects of the 2007 program.

The most significant amount of external funding, \$55,000, was received from the National Park Service Water Resource Division WCA Contingency Program for a projected titled Emergency Measures to Prevent the Introduction of Quagga and Zebra Mussels to Glen Canyon NRA. These funds allowed the following accomplishments:

- Constructed “Mussel Free” self-certification stations at each of six developed launch ramps
- Created and installed signs at six entrances and launch ramps to support self-certification system
- Produced dashboard certificates, self-certification packets, “Zap the Zebra” brochures, and other educational materials to distribute to approximately 100,000 boaters on Lake Powell in 2007
- Project goals were modified in August to respond to BOR reports of larval zebra mussels in Lake Powell
 - Surveyed marina areas for adult mussels with dive teams and a remotely operated submarine for depths over 130 feet.
 - Acquired three plankton nets specifically designed for larval mussel sampling
 - Purchased cross-polarizing compound microscope with camera for veliger analysis in the Glen Canyon NRA Wahweap Laboratory (Figure 14)



Figure 14. Veliger analysis microscope.

Zebra Mussel Prevention for 2008

Glen Canyon NRA will continue to be a national leader in mussel prevention. The interdiction, education, and monitoring actions of 2007 will be continued in 2008 with targeted expansion and improvement. The 2008 season will bring more changes for the Zebra Mussel Prevention Program, particularly necessary as a result of the continued spread

of mussels throughout the region. Operational improvements needed prior to the 2008 boating season are captured in these recommendations.

General Recommendations

- *Create Standard Operating Procedures for the Glen Canyon NRA Zebra Mussel Prevention Program* – Standard Operating Procedures are needed to document the various aspects of and roles in zebra mussel prevention that have been developed.
- *Improve coordination with the State of Arizona* – Coordination with the State of Utah has been strong, but coordination with Arizona should be improved.
- *Create an Operations Formulation System (OFS) request for new recurring costs of zebra mussel prevention* – Glen Canyon NRA management should consider all recommendations of the Zebra Mussel Interdisciplinary Team (captured in PMIS numbers 135925 and 136862). Many prevention efforts have been identified that were not possible in 2007 due to a lack of funding. These efforts are primarily recurring operational efforts that would only appropriately be funded through base funds. In light of the park's mandate to identify "core" responsibilities, management may determine that some existing operations are lower in priority than zebra mussel prevention efforts, in which case any OFS request might be focused on funding to continue the lower priority activities that cannot be accomplished due to high priority prevention efforts.

Interdiction Recommendations

- *Enforce dashboard certificate requirement* – Enforcement of the Superintendent's Compendium requirement for dashboard certificates represents the only comprehensive prevention action that the park can implement without additional funding. Dashboard certificate enforcement is not only a powerful interdiction tool that reaches every boater in the park; it is also a powerful educational tool. The full interdiction and education potential of the dashboard certificate requirement can only be attained with enforcement.
- *Update screening questions and self-certification packet* – New infestations, both in the east and west, must be accounted for in the self-certification packet. Entrance station questions should be changed to language developed by the Zebra Mussel Interdisciplinary Team that simply asks if the vessel has been in "other waters in the past 30 days." This change requires that all decontamination partners follow the inspection and decontamination protocols.
- *Formalize inspection and decontamination procedures* – Draft protocols have been developed to guide the inspection and decontamination process. These protocols were distributed to decontamination partners in 2007, but partners were not mandated to adopt all aspects of the protocols. With the increasing number of

infested water bodies in the West and the accompanying increased high-risk vessel pressure, the protocols should be finalized and their use mandated for the overall program to function. Training for partners is currently planned for May 2008. Additional partnerships should be encouraged.

- *Improve vessel decontamination compliance* – Workable procedures that improve compliance with decontamination requirements are needed. One contaminated vessel that is not in compliance could infest Lake Powell with zebra mussels, so the compliance goal should be 100%.
- *Improve compliance tracking* – New procedures are needed to ensure better tracking of decontamination compliance. New procedures are needed to track compliance of moored vessels with the decontamination requirements.
- *Develop containment strategies* – Glen Canyon NRA has a responsibility to prevent the spread of any zebra mussel infestation that occurs within the park. While there is currently no credible evidence of infestation, an undiscovered infestation could still exist. Containment strategies are included in the NPS Quagga/ Zebra Plan based on Lake Mead's actions. The elements in the plan should be adapted and carried out for Glen Canyon NRA.
- *Create a rapid response plan* – A Glen Canyon NRA-specific rapid response plan would aid the park greatly in the event that mussels are confirmed in Lake Powell. The NPS Quagga/ Zebra Plan provides guidelines for rapid response plans. Any pre-planning that is possible should be accomplished to minimize delays to time critical actions.
- *Create Hazard Analysis and Critical Control Points (HACCP) Plans* – HACCP Plans should be developed for all Glen Canyon NRA operations that involve the transport of equipment. Critical examples of operations requiring HACCP Plans include dive team assistance to other parks and transport of vessels or equipment between Lake Powell and Lees Ferry or even Wahweap and Bullfrog.
- *Contain Runoff* – Runoff from the decontamination area at Halls Crossing should be contained to eliminate the potential for the wastewater from watercraft decontaminations to infect Lake Powell with mussels.

Education Recommendations

- *Continue and enhance educational efforts* – Educational efforts at Glen Canyon NRA have been strong, but there is need for improvement. Signs are needed in remote areas to notify visitors of the zebra mussel threat and the dashboard certificate requirement. An interpretive display, which has been partially designed, should be completed. Signs are needed to address Glen Canyon NRA's containment responsibility.

Monitoring Recommendations

- *Develop long-term veliger monitoring* – A long-term, scientifically credible veliger monitoring program should be developed and implemented. Equipment for in-house veliger analysis has been purchased, but without additional staff, sample processing will remain very limited. PMIS number 141851 has been developed seeking FLREA funding for a monitoring program.
- *Develop buoy mounted Artificial Substrate Samplers* – An artificial substrate sampler design that reaches deeper into the lake should be developed. Current planning involves a buoy at major launch ramps with substrates attached at multiple depths from the surface to the bottom. These samplers are planned to be maintained by the Aids to Navigation team at Glen Canyon NRA.
- *Resolve laboratory discrepancy* – The discrepancy in veliger results between the BOR laboratory and the laboratories at Glen Canyon NRA and Portland State University should be resolved. In-house veliger analysis capability that has been developed at Glen Canyon NRA makes resolution less critical for the park, but effort should be made to resolve the issue because all veliger sampling in the West is compromised if the BOR laboratory is incorrectly identifying ostracods as zebra mussel veligers.
- *Consider in-house PCR* – Polymerase chain reaction testing has limitations, but still represents a powerful tool that Glen Canyon should consider developing the capability to use in-house.

Glen Canyon's long history of zebra mussel prevention serves as an example of responsible management for water resource managers throughout the country. Few examples exist of such effective, proactive efforts. The program has already confounded the prediction of the Utah Aquatic Nuisance Species Action Team that Lake Powell would be the first western water body to become infested. A decade after that prediction, there have been many changes in the zebra mussel infestation of the western hemisphere, but through Glen Canyon NRA's efforts, Lake Powell likely remains zebra mussel-free.

